Scientific Note

AQUATIC MACROINVERTEBRATE RESPONSE TO SHORT-TERM HABITAT LOSS IN EXPERIMENTAL POOLS IN THAILAND

Biotic interactions can cause community structures to change temporally so that new communities in recently disturbed habitats differ from established ones in similar undisturbed habitats (Sousa, W. P. 1979. Ecology, 60: 1225–1239). In this study, I contrasted aquatic macroinvertebrate communities in experimental pools that dried temporarily and were then reflooded to those in similar habitats that remained flooded.

This study was conducted using facilities at Chiang Mai University in northern Thailand. The conditions in natural rain-filled pools were simulated using 10 cement tanks, each 80 cm in diameter, that were flooded by rainfall in September 1990. To provide sediments for benthic invertebrates, I added 0.5 liter of soil to each tank. Tanks were paired spatially so that both tanks in each pair received similar amounts of shading and organic matter from falling tree leaves. In most cases, much of the water column in tanks eventually became filled with leaves. From September through December 1991, rainfall kept experimental pools flooded and aquatic invertebrate communities developed naturally within them.

With the onset of Thailand's winter dry season in December, the pools began to dry. When water depths in tank pairs had declined to approximately 2 cm, I randomly selected one member of each pair to be refilled to a depth of 4 cm by adding 10 liters of tap water per tank; water was left standing for 24 h prior to introduction to allow chlorine to dissipate. Water in all of the tanks continued to evaporate, and the unfilled tanks in each of the five pairs dried completely during late January. An examination of the dry leaves and sediments in these tanks revealed no live aquatic invertebrates. These tanks were allowed to remain dry for 48 h.

I then refilled these disturbed tanks to a depth of 4 cm by adding 20 liters of water per tank. Concurrently, 10 liters of water was added to the non-dried tank of each pair. I continued to add equal amounts of water to paired tanks, as needed, to maintain depths of at least 2 cm; in mid-March, all tanks were allowed to dry. Thus, in this experiment, identical volumes of water were added to paired tanks but one half of each pair was disturbed by drying for two days in January whereas the other retained water from September through March.

In early February, 10 days after January refloodings of dried tanks, macroinvertebrates in each of the five tank pairs were sampled. A 10-cm by 6-cm net (0.1-mm mesh) was swept across a randomly selected transect spanning each tank's 80-cm diameter; the distal edge of the net was scraped along the bottom so that benthic invertebrates were collected. This technique had the desirable feature of not being destructive to the habitats but probably under-sampled benthic and fast-swimming organisms. Thus, for the sample collected at the experiment's end in mid-March, I vigorously stirred the water and sediments for 1 min and

Table 1. Numbers of macroinvertebrates collected from experimental tanks that had been disturbed by drying and reflooding in January 1991 compared to numbers in paired habitats that did not dry (undisturbed). The February sweep-net samples were collected 10 days after disturbed habitats were reflooded. For March samples, collected six weeks after refloodings, water and sediments were stirred vigorously before sweep netting to increase capture efficiency for benthic organisms.

| Taxa | February samples | | March samples | |
	Disturbed habitats (number per sweep [SE])	Undisturbed habitats (number per sweep [SE])	Disturbed habitats (number per sweep [SE])	Undisturbed habitats (number per sweep [SE])
Ephemeroptera				
Baetidae	6 (2)	4 (2)	23 (32)	15 (21)
Diptera				
Culicidae	59 (14)	6 (5)[a]	35 (11)	1 (0)[a]
Chironomidae	12 (6)	7 (1)	92 (45)	76 (6)
Ephydridae	8 (2)	3 (1)	<1	<1
Ostracoda	3 (2)	179 (113)[a]	116 (116)	163 (69)

[a] Numbers differed significantly (paired t-test; $P < 0.05$) between treatments.

swept the net through the slurry, selecting transects as above. The numbers of macroinvertebrates collected per treatment were contrasted using paired t-tests.

In February samples (Table 1), numbers of seed shrimp (Ostracoda) in the disturbed habitats were < 2% of those in undisturbed habitats (3 ± 2 ostracods/ sweep vs. 179 ± 113 ostracods/sweep; paired t-test, $P < 0.01$). Ostracod immatures and adults are noted for their ability to tolerate drought if sediments remain humid (Wiggins, G. B., R. J. Mackay & I. M. Smith. 1980. Archiv f. Hydrobiol. Supple., 58: 97–206), so their reductions from January dryings suggests the disturbance from drought was severe. However, numbers of *Culex quinque-fasciatus* Say mosquito larvae (Diptera: Culicidae) were 10 times greater in habitats that had dried in January and were reflooded for only 10 days than in habitats that had retained water since September (59 ± 14 larvae/sweep {1 SE} vs. 6 ± 5 larvae/sweep; paired t-test, $P < 0.01$). In addition, analyses (paired t-tests, $P > 0.05$) failed to detect density differences between disturbed and undisturbed habitats for the other common invertebrates such as midge larvae (Diptera: Chironomidae) (12 ± 6 larvae/sweep vs. 7 ± 1 larvae/sweep), brine fly larvae (Diptera: Ephydridae) (8 ± 2 larvae/sweep vs. 3 ± 1 larvae/sweep), and mayfly nymphs (Ephemeroptera: Baetidae) (6 ± 2 nymphs/sweep vs. 4 ± 2 nymphs/sweep). Clearly, rates of recolonization and development by these insect species were rapid. I occasionally saw predators such as dragonfly nymphs (Odonata: Libellulidae) and backswimmer adults (Hemiptera: Notonectidae) in undisturbed tanks but these organisms were rare and were not collected in sweep samples.

In March, samples (Table 1), collected six weeks after January refloodings, mosquito larvae were still abundant in the habitats that dried in January, and significantly more larvae were collected there than in habitats that had not dried (35 ± 11 larvae/sweep vs. 1 ± 0 larva/sweep; paired t-test, $P < 0.01$). By March, ostracod numbers in the habitats that dried in January had rebounded so that numbers were no longer significantly different in disturbed vs. undisturbed habitats (116 ± 116 ostracods/sweep vs. 163 ± 69 ostracods/sweep; $P > 0.05$).

Although the capture efficiency for mosquitoes and ostracods appeared to be similar for the two sampling variations used in February and March, the stirring of the sediments prior to sweep netting clearly increased the capture rates of benthic midges and mayflies in March. I collected 92 ± 45 midge larvae/sample in disturbed habitats, and 76 ± 6 larvae/sample in undisturbed ones. For mayflies, 23 ± 32 nymphs/sample were collected in disturbed habitats vs. 15 ± 21 nymphs/sample in undisturbed habitats. However, as in the February sample, midge and mayfly numbers during March did not differ significantly between treatments ($P > 0.05$). Brine fly larvae were rare during March.

Although disturbance from drying and reflooding habitats is known to benefit *Aedes* spp. and other mosquitoes that have desiccation resistant eggs (Wiggins et al. 1980), the temporary drawdowns in this study also increased densities of *Culex* mosquitoes, which do not have desiccation resistant eggs. The greater numbers of mosquito larvae in the drought disturbed habitats may have been related to differences in water chemistry between treatments, which may have influenced oviposition rates or larval survivals. Water pH was lower in disturbed habitats than in undisturbed habitats (8.1 ± 0.4 vs. 8.5 ± 0.2, respectively; $P < 0.05$, paired t-test). The water in the tanks that dried was in all cases also visibly darker brown than in corresponding tanks that had remained flooded, suggesting greater concentrations of humic materials. Although shallow, organic-rich habitats with few predators are considered to be prime habitats for mosquito larvae (Laird, M. 1988. The natural history of larval mosquito habitats. Academic Press, New York), this axiom applied only to habitats that temporarily became dry and not to habitats that remained flooded.

Aside from the strong responses to drying by mosquitoes, the remaining macroinvertebrates showed little response to the disturbance. Keys were not available to determine species compositions of the immature insects (except mosquitoes), so the failure to detect response at the community level may be in part a product of low taxonomic resolution. However, all common species occurred in both treatments. Alternatively, a combination of rapid rates of recolonization and growth in the warm tropical conditions may have limited the impact of disturbance in these pools. Although January dryings appeared to kill all invertebrates in the disturbed habitats, the fast-maturing insects present in the undisturbed habitats during January probably also disappeared shortly thereafter via emergence. Subsequent recolonization of both habitat types was rapid, and colonizers (except for mosquitoes) failed to differentiate between disturbed and undisturbed habitats. Thus, disturbance may be less important to community development in habitats dominated by fast-growing immature insects than in habitats dominated by other types of organisms (e.g., Power, M. A. & A. J. Stewart. 1987. Amer. Midl. Naturalist, 117: 333–345).

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